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Report

Cooba Solar Farm Flood Impact Assessment Existing Conditions

Venn Energy

12 July 2024

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1 INTRODUCTION

1.1 Objectives

The primary objective of this project is to provide Venn Energy a better understanding of potential flood risk and inundation at the subject site. To do this the following was completed:

- Development of a hydrology model (using RORB) to determine critical duration inflows to the site. This included overland flow paths and riverine flows.
- Development of a 2D (two-dimensional) hydraulic model (using TUFLOW) to assess flood risk from surface water runoff and riverine inundation during storm events.
- Waterway assessment and site visit to describe the "poorly defined waterways" that are mapped within the proposed extent of the solar farm.

1.2 Site

The proposed solar farm site is located at 124 Cornella Church Road, south of Colbinabbin and north of Cornella. The site includes several parcels and is broadly bordered by Cornella Creek to the east and Heathcote-Rochester Road to the west. Yallagalorrah Creek passes through the site and outfalls to Cornella Creek downstream of the site. Myola Road, Cornella Church Road and Plain Road all intersect the site with overland flows conveyed through culverts and under bridges. The site generally drains towards Cornella Creek in a north-east direction.

The site is approximately 1,000 ha and covered by agricultural open space. Some vegetated areas are found along the watercourses.

The Cornella and Yallagalorrah Creeks are fed by an upstream catchment consisting of agricultural open space and native vegetation bushlands. A steep upstream catchment to the west of the site consists of open paddocks.

A minor portion of the site along Cornella Creek is covered by Land Subject to Inundation Overlay (LSIO); however, most of the site and the proposed panel array in not covered by LSIO. The proposed solar farm site and existing LSIO can be seen in Figure 1-1.

1.3 Methodology

The flood risk assessment for the subject site was based on hydrologic and hydraulic modelling of the Cornella and Yallagalorrah Creek catchments as well as the western catchment draining to the site. Hydrology for the investigation was modelled using RORB software which produced design flow hydrographs in the catchment in line with Australian Rainfall and Runoff 2019 (ARR19) guidelines. Flow hydrographs from key areas within the RORB model were placed into a hydraulic model (TUFLOW) where the flows were routed through the topography of the site and surrounding area to determine the maximum extent, depth, and velocity of the 1% AEP storm event.

Outputs from the hydraulic model will then be used to inform recommendations regarding the placement of infrastructure.

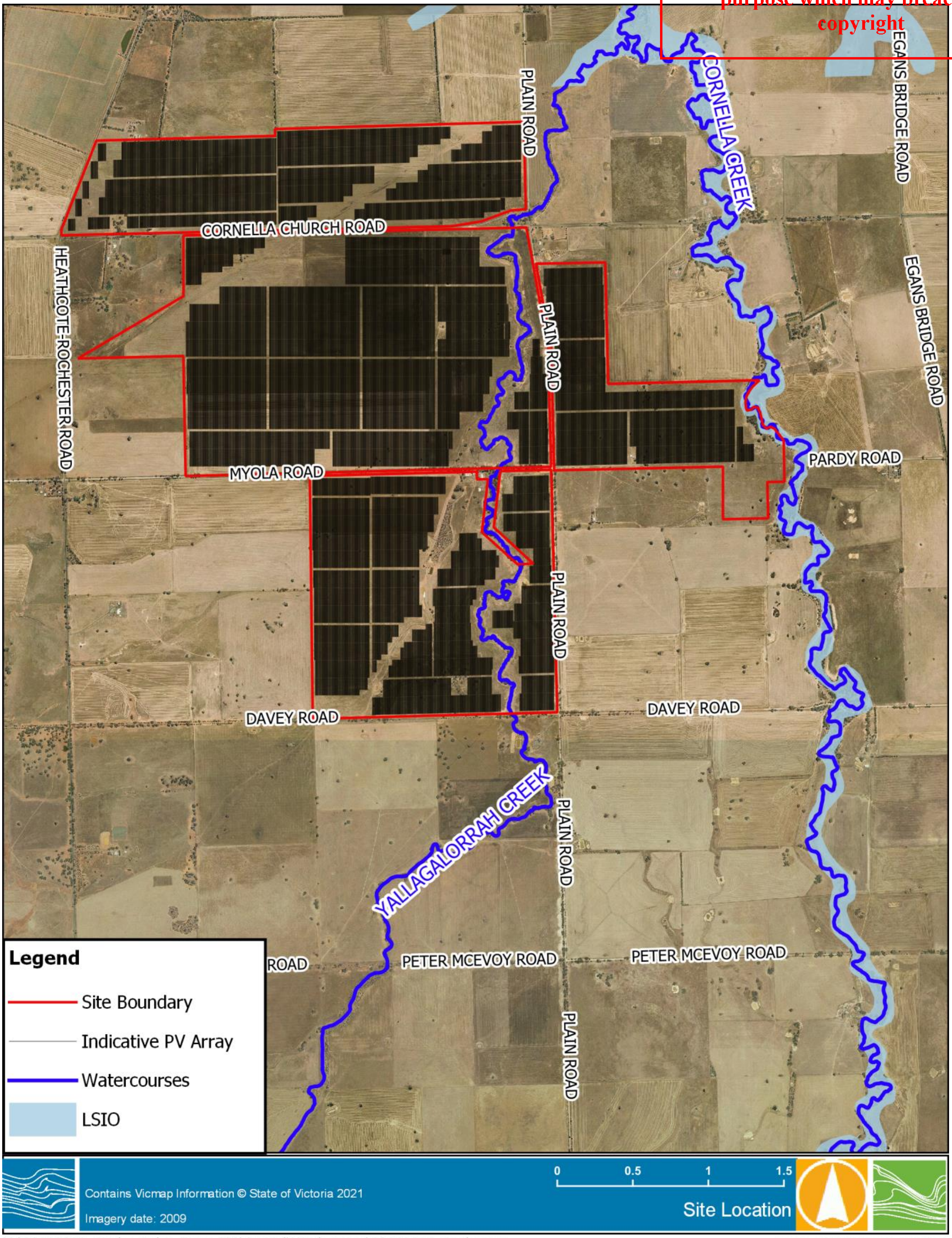

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Figure 1-1 Location of the Subject Site

2 HYDROLOGY

2.1 Overview

The hydrologic assessment used a runoff routing approach, modelled using RORB software. Design modelling was completed using both the Monte-Carlo and Ensemble approaches within RORB, as recommended in the Australian Rainfall and Runoff guidelines (ARR2019).

The methodology for determining the 1% AEP design flows using RORB at the site is summarised below:

- RORB model development.
- Catchment delineation.
- Determination of ‘kc’ and ‘m’ model parameters.
- Design inputs (e.g. rainfall, temporal patterns).
- Model verification.
- Selection of critical storm duration and appropriate temporal pattern for design hydrographs.
- Extraction of inflow hydrographs for hydraulic modelling.

Details of these steps is provided in the following sections.

2.2 Catchment Delineation

The catchment contributing to the study site was delineated based on 20m resolution topography data processed in ESRI.

The resulting delineated subareas were then input into ArcRORB to create a series of nodes and reaches, which represent the routing characteristics of the catchment to be used in the RORB model. The reaches were all defined as ‘natural’. This definition was derived from expected flow characteristics based on the aerial photography. No impervious areas were identified in the catchment.

The resulting RORB model had 89 sub-catchments encompassing a total catchment area of approximately 243 km^2, with the subject site located towards the lower end of the catchment as shown in Figure 2-1.

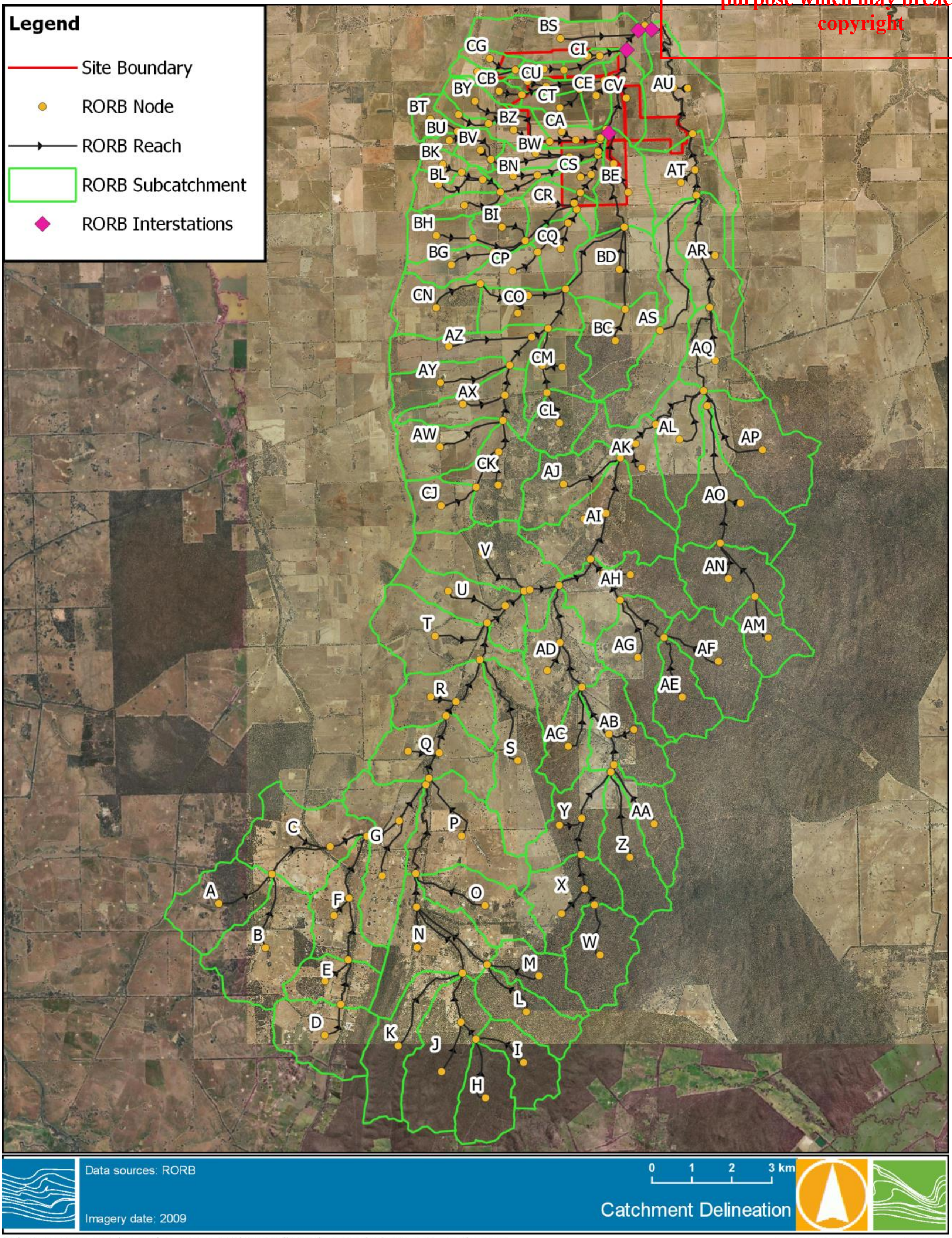

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Figure 2-1 RORB Model Catchment Delineation

2.3 Critical Duration

Two Monte-Carlo Assessments were undertaken to determine the critical storm durations impacting the proposed development site from each major waterway. Due to the size of the Cornella Creek upstream catchment, areal temporal patterns were used for this assessment. For Yallagalorrah Creek and the smaller catchments west of site, point temporal patterns were used. ARR Datahub losses and a k_c based on Pearse (2002) was initially adopted to determine the critical duration. The catchment was split into 4 interstation areas due to the difference in subarea sizing, to allow for different k_c values, see Figure 2-1. The continuing loss was reduced based on regional guidelines.

Table 2-1 provides a summary of the peak flows for Cornella Creek resulting from the Monte-Carlo assessment using areal temporal patterns.

Table 2-2 provides a summary of the peak flows for the Cornella and Yallagalorrah Creeks as well as the other locations used as inflow locations for the hydraulic model for a range of storm durations. The inflow locations can be seen in Figure 3-1. This assessment indicated that the 12-Hour duration is likely to be the critical event for the Cornella Creek, whereas the Yallagalorrah Creek and local runoff catchments have shorter critical durations.

Table 2-1 1% AEP Monte-Carlo Critical Duration with Areal Temporal Patterns (Peak Flows in m^3/s)

Duration	12-Hour	18-Hour	24-Hour	36-Hour	48-Hour
Cornella Creek	**129.75**	108.44	97.14	78.95	77.52

Table 2-2 1% AEP Monte-Carlo Critical Duration with Point Temporal Patterns (Peak Flows in m^3/s)

Duration	1-Hour	1.5-Hour	2-Hour	3-Hour	4.5-Hour	6-Hour	9-Hour	12-Hour
Cornella Creek	79.59	87.72	97.58	101.83	123.11	130.83	135.15	**138.64**
Yallagalorrah Creek	26.09	33.32	35.86	37.6	43.83	**45.37**	43.52	44.04
Inflow AS	6.43	7.80	8.03	7.60	8.19	**8.50**	7.52	7.35
Inflow BN	5.26	6.70	7.31	7.37	8.02	**8.08**	6.90	7.27
Inflow BW	8.54	10.82	11.61	11.86	13.12	**13.47**	11.87	12.15
Inflow CS	14.58	18.71	19.91	19.51	**21.59**	21.52	18.51	19.32
Inflow CA	5.26	6.70	7.25	7.18	**7.84**	7.74	6.83	6.91
Inflow CE	8.73	**10.16**	9.86	9.29	9.47	9.85	7.74	7.78
Inflow CI	2.70	3.40	3.72	3.81	4.29	**4.35**	3.81	3.94

2.4 Routing Parameters

No streamflow gauges or previous flood information exists for the site to calibrate the RORB model. Prediction equations for ungauged catchments were used to inform the selection of a 'reasonable' routing parameter, kc. McMahon and Muller (1983) showed that k_c is directly proportional to the average flow distance (d_{av}). The relationship is expressed as: $k_c = C_{0.8}\, d_{av}$, where, $C_{0.8}$ is a characteristic of the catchment that is independent of catchment size, and d_{av} is the weighted average flow distance of all RORB model nodes to the catchment outlet. Pearse et al. (2002) determined a relationship for k_c based on 39 Victorian catchments from the Hansen et al. (1986) study. The relationship is expressed as $k_c = 1.25 d_{av}$. Using the Pearse et al. relationship, k_c was determined for 4 different interstation areas with different range of d_{av}.

The adopted k_c values are shown in Table 2-3. The resulting flow was then verified against the ARR Regional Flood Frequency Estimation Model (RFFE) and a number of other flow estimates discussed in more detail in Section 2.6.

Table 2-3 Adopted k_C Values

Area	k_c
Cornella Creek Catchment area	29.18
Yallagalorrah Catchment area	10.03
Western Catchment area	6.60
Northwest Catchment area	2.77

2.5 Design Input

2.5.1 Intensity-Frequency-Duration (IFD)

Rainfall depths for the 1% AEP event were estimated for the centroid of the subject site using the Intensity-Frequency-Duration (IFD) information available from the Bureau of Meteorology. The design rainfall IFD estimates for the study area are shown in Table 2-4.

Table 2-4 1% AEP Design Rainfall Depths (mm)

Duration	1 hr	1.5 hr	2 hr	3 hr	4.5 hr	6 hr	9 hr	12 hr
Rainfall	56.5	62.3	66	71.1	76.2	80.2	86.9	92.7

2.5.2 Temporal Patterns

The design storm temporal patterns were downloaded from the ARR2019 Data Hub and were used to simulate the distribution of burst rainfall depth during each storm event modelled. Areal temporal patterns were used for Cornella Creek and point temporal patterns for remaining inflow locations due to the varying critical duration of each inflow. Each of the 10 Temporal Patterns was selected and compared for the peak flow at each inflow location. The temporal pattern generating the peak flow closest to the Monte Carlo peak flow was selected for each duration.

2.5.3 Design Losses

An initial/continuing loss model was applied for the RORB modelling. Losses were initially determined using the ARR online datahub. The suggested losses were 25 mm initial loss and 4.6 mm/hr continuing loss. The data hub continuing loss of 4.6 mm/hr was lowered based on recent reviews of these losses indicating that they are too high and that consideration should be given to regionally appropriate losses where information is available. Having regard to this a continuing loss of 2.76 mm/hr was adopted (60% of ARR continuing loss).

2.6 Model Verification

Verification of the adopted kc and rainfall losses were estimated by comparing the RORB modelled peak flows at the model outlet with the peak flows produced by the ARR Regional Flood Frequency Estimation (RFEE) method (Rahman et al, 2012), the Probabilistic Rational Method, VicRoads Rational Method and hydrological recipe estimate. These have been used in this study for further verification in the absence of available gauge data.

Using the kc values listed above based on Pearse et al (2002) with an initial loss of 25 mm and continuing loss of 2.76 mm/hr, produced a RORB model peak flow for the 1% AEP within the range of design estimates discussed above. This suggests the parameters adopted within the RORB model are suitable for the 1% AEP flow estimate. A comparison of peak flows between the RORB model and flow estimates is shown in Table 2-5.

Table 2-5 1% AEP Peak Flow Estimates

1% AEP Estimation Method	Peak Flow (m^3/s)
RFFE	132
RORB	154
Rational Method	209
VicRoads Rational Method	209
Hydrological Recipes	309

2.7 RORB Results

The Australian Rainfall and Runoff (2019) recommended approach for determining the 1% AEP event has been followed and discussed above. A summary of the adopted model parameters is provided in Table 2-6.

Table 2-6 Adopted RORB Model Parameters for Design Modelling

Parameter	Adopted Value
k_c	2.77 – 29.18 (see above)
m	0.8
IL	25 mm
CL	2.76 mm/hr

The critical duration for each catchment upstream of a hydraulic model inflow location was determined. The temporal patterns that produced flows close to the Monte-Carlo peak flows flow were adopted. Hydrographs for each inflow location were extracted and applied to the TUFLOW model based on the results of this assessment. The design hydrographs were simulated in a single hydraulic model simulation to represent the critical duration for each of the inflow locations.

2.8 Climate Change Consideration

The impact of projected climate change under Representative Concentration Pathway (RCP) 8.5 was considered in accordance with the recommendations in Book 1, Chapter 6 of Australian Rainfall and Runoff 2019. The interim climate change scaling factors were downloaded from the ARR datahub and are presented in Table 2-7 below.

The 1% AEP IFDs were increased by 20.2%, corresponding to the projected increase in rainfall intensity to the year 2090 under RCP8.5. The scaled 1% AEP IFDs are shown in Table 2-8 below. The RORB model was then run with the increased IFDs with the critical durations determined as per the method described above. The RORB results and critical flows are shown in Table 2-9 and Table 2-10 below.

Table 2-7 Climate Change Scaling Factors (ARR datahub)

Year	RCP 4.5	RCP6	RCP 8.5
2030	0.816 (4.1%)	0.726 (3.6%)	0.934 (4.7%)
2040	1.046 (5.2%)	1.015 (5.1%)	1.305 (6.6%)
2050	1.260 (6.3%)	1.277 (6.4%)	1.737 (8.8%)
2060	1.450 (7.3%)	1.520 (7.7%)	2.214 (11.4%)
2070	1.609 (8.2%)	1.753 (8.9%)	2.722 (14.2%)
2080	1.728 (8.8%)	1.985 (10.2%)	3.246 (17.2%)
2090	1.798 (9.2%)	2.226 (11.5%)	**3.772 (20.2%)**

Table 2-8 1% AEP RCP8.5 2090 Design Rainfall Depths (mm)

Duration	1 hr	1.5 hr	2 hr	3 hr	4.5 hr	6 hr	9 hr	12 hr
Rainfall	67.9	74.9	79.3	85.5	91.6	96.4	104.5	111.4

Table 2-9 1% AEP Monte-Carlo Critical Duration with Areal Temporal Patterns (Peak Flows in m^3/s)

Duration	12-Hour	18-Hour	24-Hour	36-Hour
Cornella Creek	**190.72**	167.11	163.62	128.18

Table 2-10 1% AEP RCP8.5 2090 Critical Duration, Point Temporal Patterns (Peak Flows in m^3/s)

Duration	1-Hour	1.5-Hour	2-Hour	3-Hour	4.5-Hour	6-Hour	9-Hour
Cornella Creek	70.72	95.75	108.45	129.31	150.70	177.13	189.62
Yallagalorrah Creek	26.25	35.53	40.07	47.52	54.33	**63.65**	62.36
Inflow AS	6.69	8.79	9.33	10.13	10.18	**11.15**	10.33
Inflow BN	5.43	7.35	8.19	9.40	10.05	**10.98**	9.43
Inflow BW	8.56	11.58	12.97	15.11	16.64	**18.68**	16.53
Inflow CS	15.27	20.50	22.78	25.27	26.23	**28.58**	25.07
Inflow CA	5.44	7.35	8.20	9.25	9.81	**10.67**	9.21
Inflow CE	9.93	11.76	11.69	12.59	11.39	**12.82**	9.64
Inflow CI	2.73	3.70	4.15	4.88	5.43	**6.07**	5.31

3 HYDRAULIC MODEL

3.1 Model Extent

The TUFLOW model extent is represented in Figure 3-1 with inflow locations, boundary conditions and 1D structures also shown.

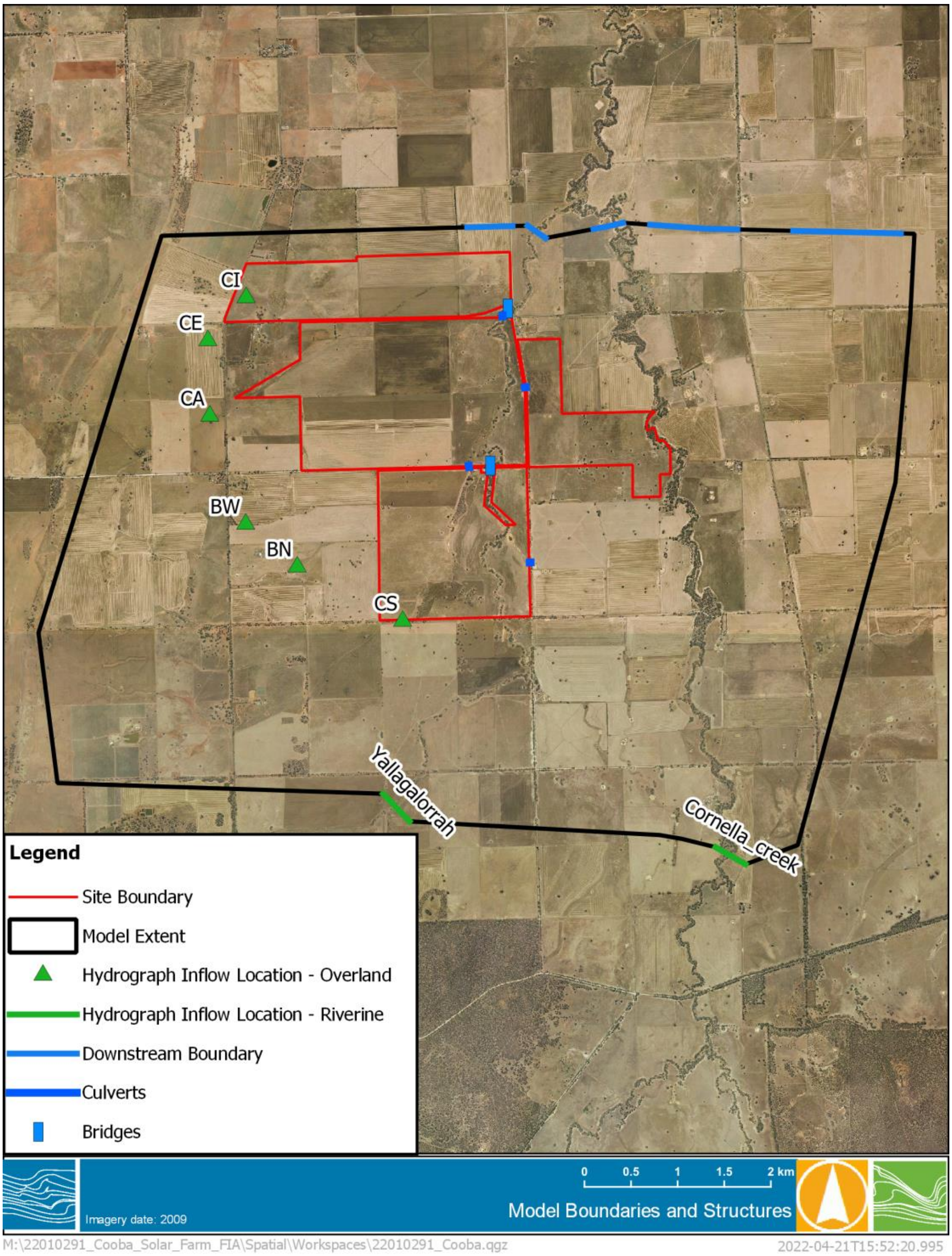

Figure 3-1 Model Extent, Boundaries and 1D Structures

3.2 Topography

The model topography was represented by a 2m x 2m grid, indicating a slope to the northwest and with a steep north-south aligned ridge along the wester model boundary, see Figure 3-2.

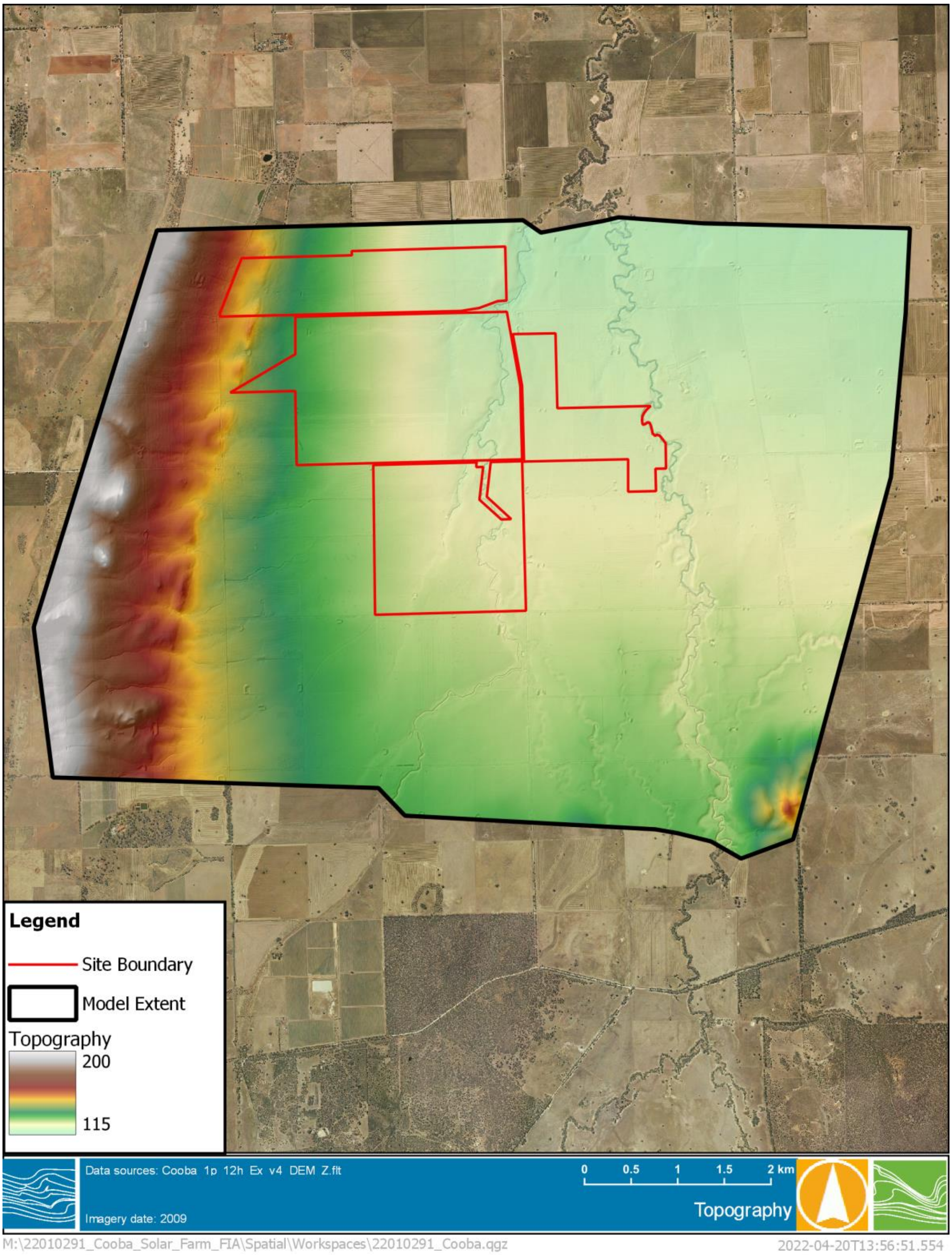

Figure 3-2 Site Topography

3.3 Boundaries

The constructed TUFLOW model comprised of two riverine inflow locations (Cornella and Yallagalorrah Creeks), modelled as 2d_bc inflows and an additional 7 inflow locations representing overland flow (2d_sa) that referenced hydrographs developed from the RORB model. The riverine inflows were located in the main waterways at the model extent and the remaining source inflows are located upstream of the subject site in localised depressions that are likely to be overland flow paths.

Several tailwater boundaries (2d_bc) were added to allow water to exit the model. Boundaries were added in the main waterways and at locations where overland flow paths reached the model boundary. The outflow was represented using 2D water level versus discharge relationships (HQ type) with slopes corresponding to the local floodplain slope, permitting water to exit the model without influencing water levels at the site.

3.4 Structures/1D

The following culverts and bridges were included in the hydraulic model based on measurements and photos collected by the landholder:

- Two 0.3 m circular culverts under Plain Road, one partially blocked
- 1.5 m circular culvert under Myola Road
- 1.2m x 0.3 m box culvert for Yallagalorrah Creek under Cornella Church Road
- Myola Road Bridge over Yallagalorrah Creek with obvert 3.5 m above ground
- Plain Road Bridge over Yallagalorrah Creek with obvert 2.5 m above ground

The 1D structures can be seen in Figure 3-1.

3.5 Model Summary

The hydraulic model was developed using TUFLOW software and employing a boundary and source inflow modelling approach. The model was run for the 1% AEP event to determine the current flooding conditions of the site. The design hydrographs were simulated in a single hydraulic model simulation to represent the critical duration for each of the inflow locations. A summary of the model parameters used are shown in Table 3-1 below.

Table 3-1 TUFLOW Model Summary

Terrain	The base terrain of the model was derived from LiDAR captured in 2010 and 2020 with a 1 metre grid resolution.
Inflow Boundary Regime	Boundary and source inflow methodology was used based on the runoff hydrographs extracted from the RORB model. Two inflow locations from waterways and seven inflows from overland flow paths. Flows downstream of the site were verified against several methods to determine peak runoff, this was covered in more detail in Section 2.6.
Inflow Peak Cornella Creek	1% AEP 12-hour event: 127.89 m^3/s
Inflow Peak Yallagalorrah Creek	1% AEP 6-hour event: 43.28 m^3/s
Inflow Peak AS	1% AEP 6-hour event: 7.97 m^3/s

Inflow Peak BN	1% AEP 6-hour event: 7.91 m^3/s
Inflow Peak BW	1% AEP 6-hour event: 13.16 m^3/s
Inflow Peak CS	1% AEP 4.5-hour event: 18.66 m^3/s
Inflow Peak CA	1% AEP 4.5-hour event: 6.96 m^3/s
Inflow Peak CE	1% AEP 1.5-hour event: 7.83 m^3/s
Inflow Peak CI	1% AEP 6-hour event: 4.28 m^3/s
Tailwater Boundary	2d_bc – Type HQ (water level-flow)
Model Type	TUFLOW HPC
Model Build	2020-10-AC-iSP
Hydraulic Roughness	Manning's 'n' values were attributed to different land use or surface types. The adopted manning's 'n' values are as follows: ■ Open space, minimal vegetation – 0.04 ■ Open space, moderate vegetation – 0.08 ■ Roads – 0.02 ■ Waterways – 0.3
Losses	■ IL = 25 mm ■ CL = 2.76 mm/hr
Model Cell Size	2 x 2 m
1D Negative Depths	0
2D Negative Depths	0
Peak Cumulative Mass Error	0.00%

3.6 Flood Hazard Classification

Floods can be hazardous, producing harm to people, damage to infrastructure and potentially loss of life. In examining the potential hazard of flooding at the subject site several factors were considered, as outlined in ARR 2019 (Book 6 Chapter 7). The assessment of flood hazard considered the following:

- Velocity.
- Depth.
- A combination of velocity and depth.

The flood hazard of the site was assessed in accordance with ARR2019, which defines six hazard categories. The combined flood hazard curves are presented in Figure 3-3 and the 1% AEP flood hazard results are shown in Figure 4-4.

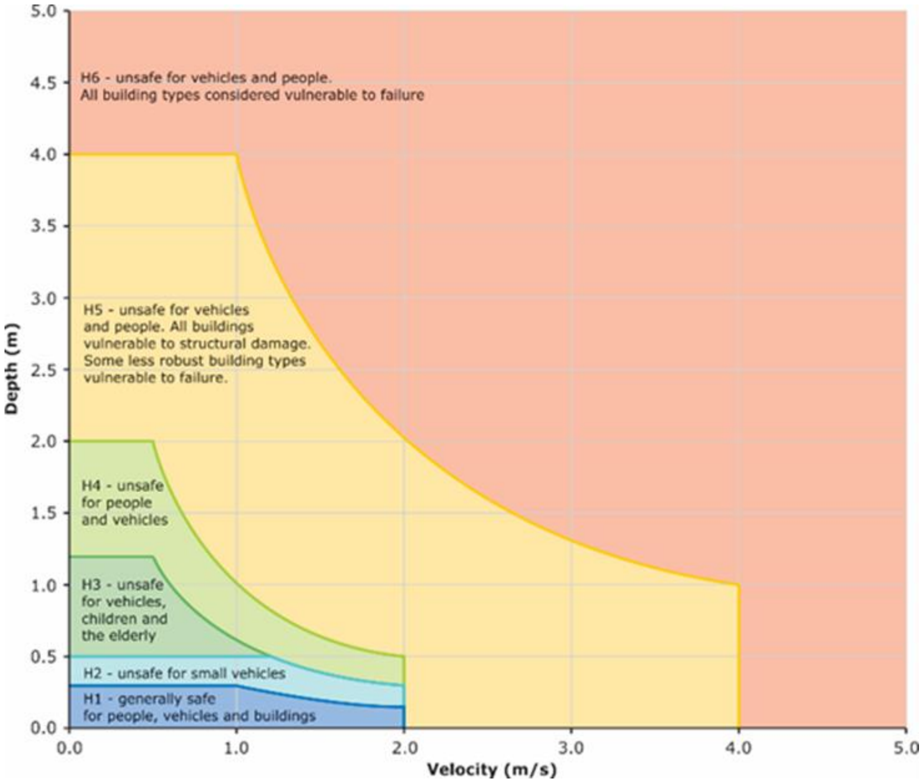

Figure 3-3 Flood Hazard Curves

4 RESULTS

The hydraulic model was simulated for the 1% AEP event with the extracted RORB hydrographs for the critical duration at each inflow location. The results are discussed in this section with plots presenting the current flooding conditions at the subject site from Cornella Creek, Yallagalorrah Creek and overland flow paths.

4.1 Present Day 1% AEP

The 1% AEP flood depth, velocity and hazard results are shown in Figure 4-1 to Figure 4-4.

The result shows that the flow in Cornella Creek is confined to the river channel until crossing Davey Road. North of Davey Road the flow in Cornella Creek leaves the channel and spreads over a wide area. Flood depths outside the river channel (and farm dams) reach up to approximately 0.9 m. The Yallagalorrah Creek flow is mostly confined to the river channel. There is widespread overland flow from the waterways stemming from the steep ridge west of the site; however, the depth is generally below 0.2 m excluding open drains, riverbeds and flooding upstream of road embankments.

The flow velocity is below 2 m/s outside of the river channels, and for a majority of the site the velocity is below 0.5 m/s.

Flood hazard results indicate that most of the areas within the subject site that is impacted by flooding is classified as H1, with other categories only found outside of the river channels.

4.2 Projected (Climate Change) 1% AEP

The 1% AEP flood depth, velocity and hazard results for the RCP8.5 2090 simulation are shown in Figure 4-5 to Figure 4-8.

The climate change results are generally similar to the present day results for much of the site. Compared to the present-day 1% AEP event, flood levels from the overland paths to the west increase slightly, with increases of <2cm common across much of the site. The creek channels experience larger increases in flood levels, ranging from ~10cm increases at the south end of the site to >30cm at the north in Yallagalorrah Creek. Cornella Creek also experiences increases in flood level, however the broad floodplain distributes the increased flow (and thus level) over a wide area. Increases at and adjacent to the site range from 5cm to 15cm.

Flood velocities see minor increases compared to the present day scenario but generally remain less than 1 m/s across the site. Similarly, increases in flood hazard are limited in area with the majority of the site classified as H1, however there is a small area of H4 towards the north of the site in the climate change scenario.

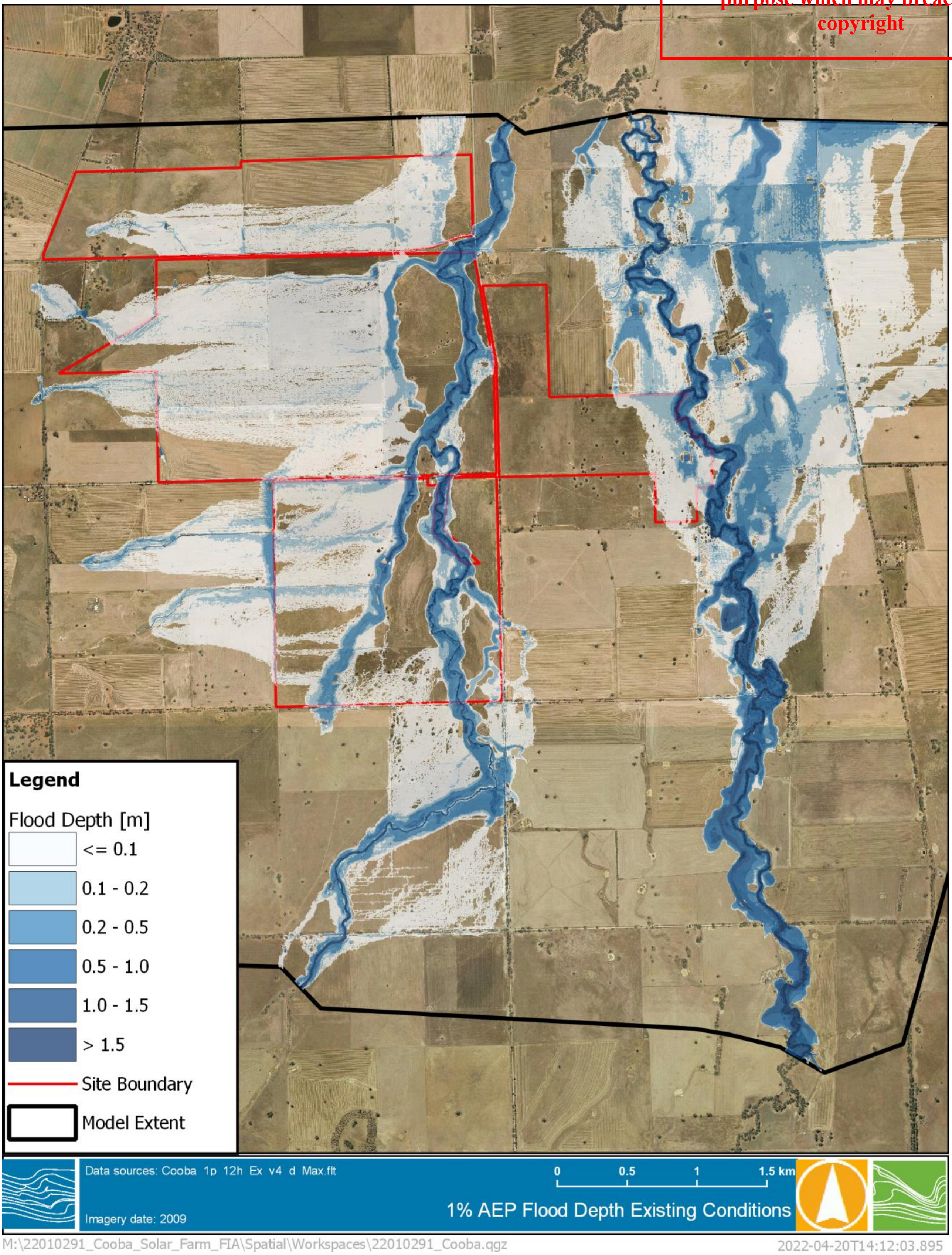

Figure 4-1 1% AEP Flood Depth – Existing

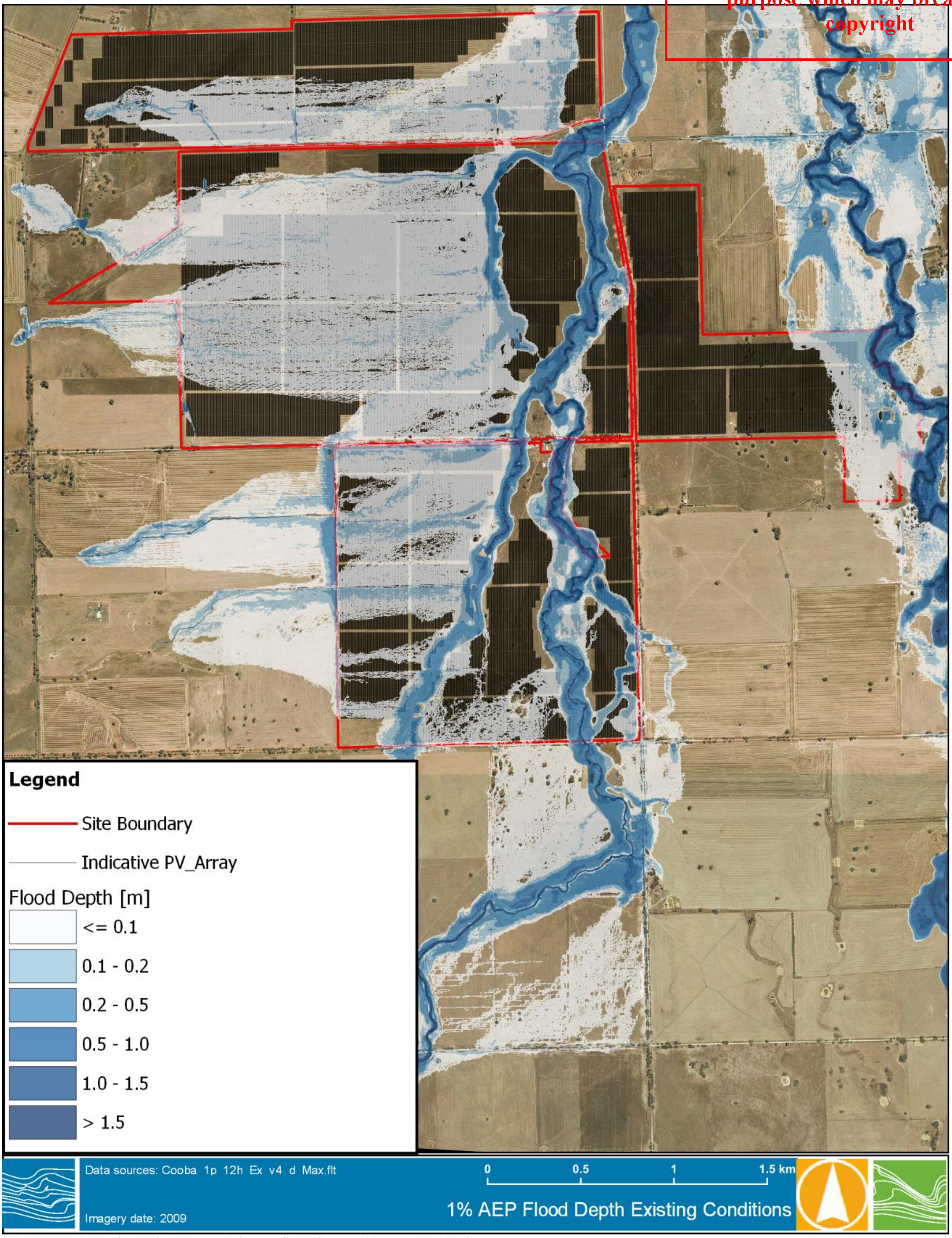

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Figure 4-2 1% AEP Flood Depth with Indicative PV Array– Existing

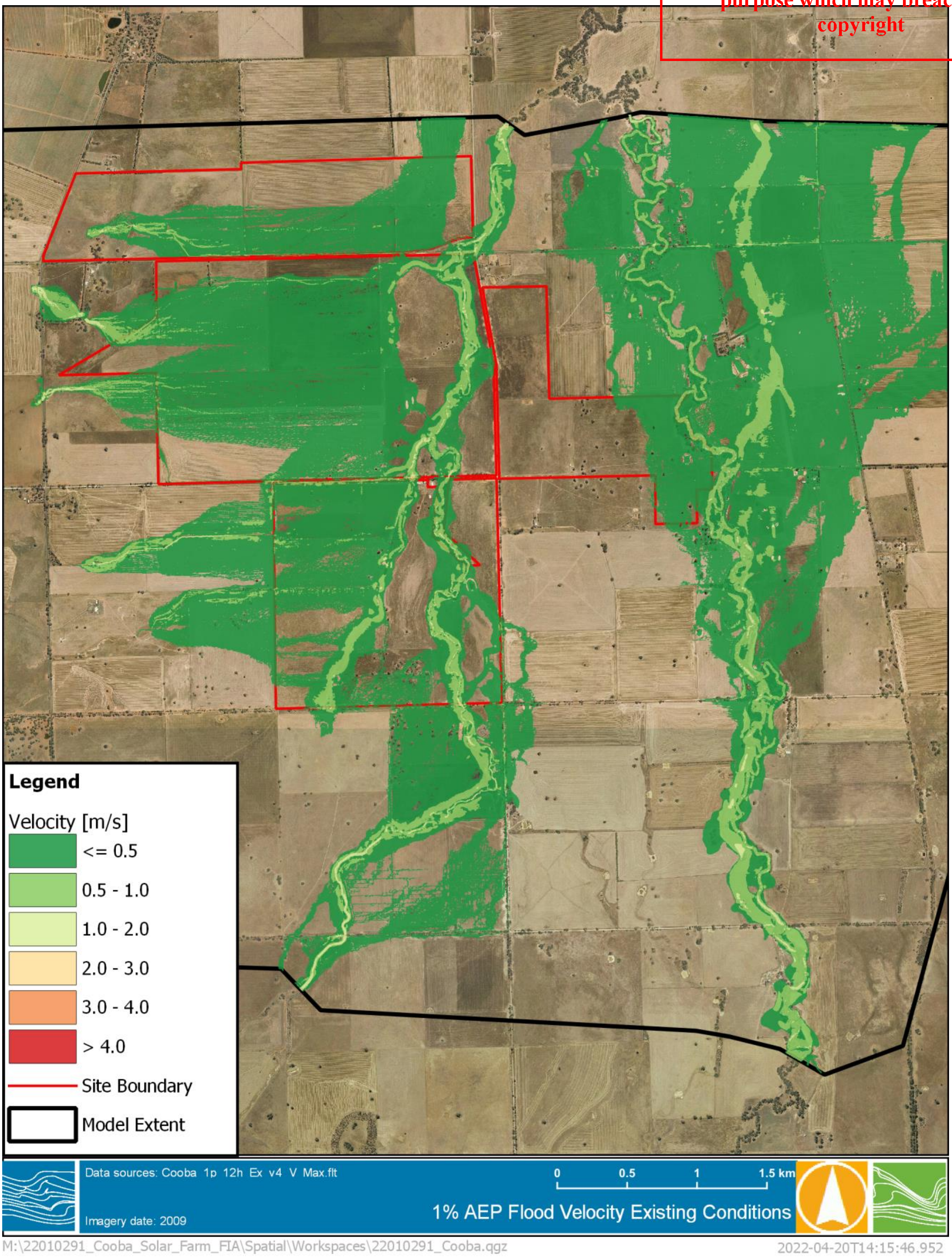

Figure 4-3 1% AEP Flood Velocity – Existing

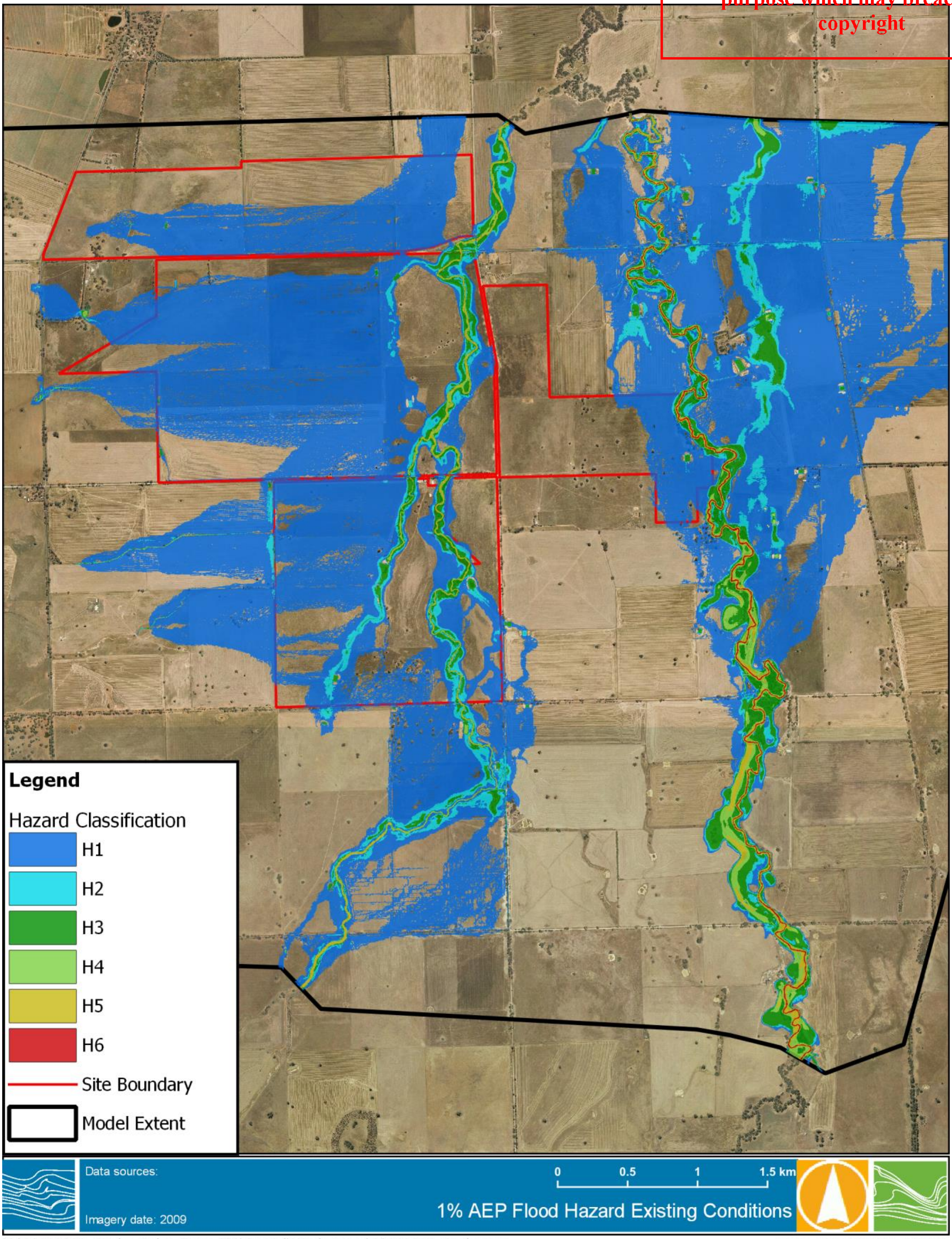

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Figure 4-4 1% AEP Flood Hazard Classification – Existing

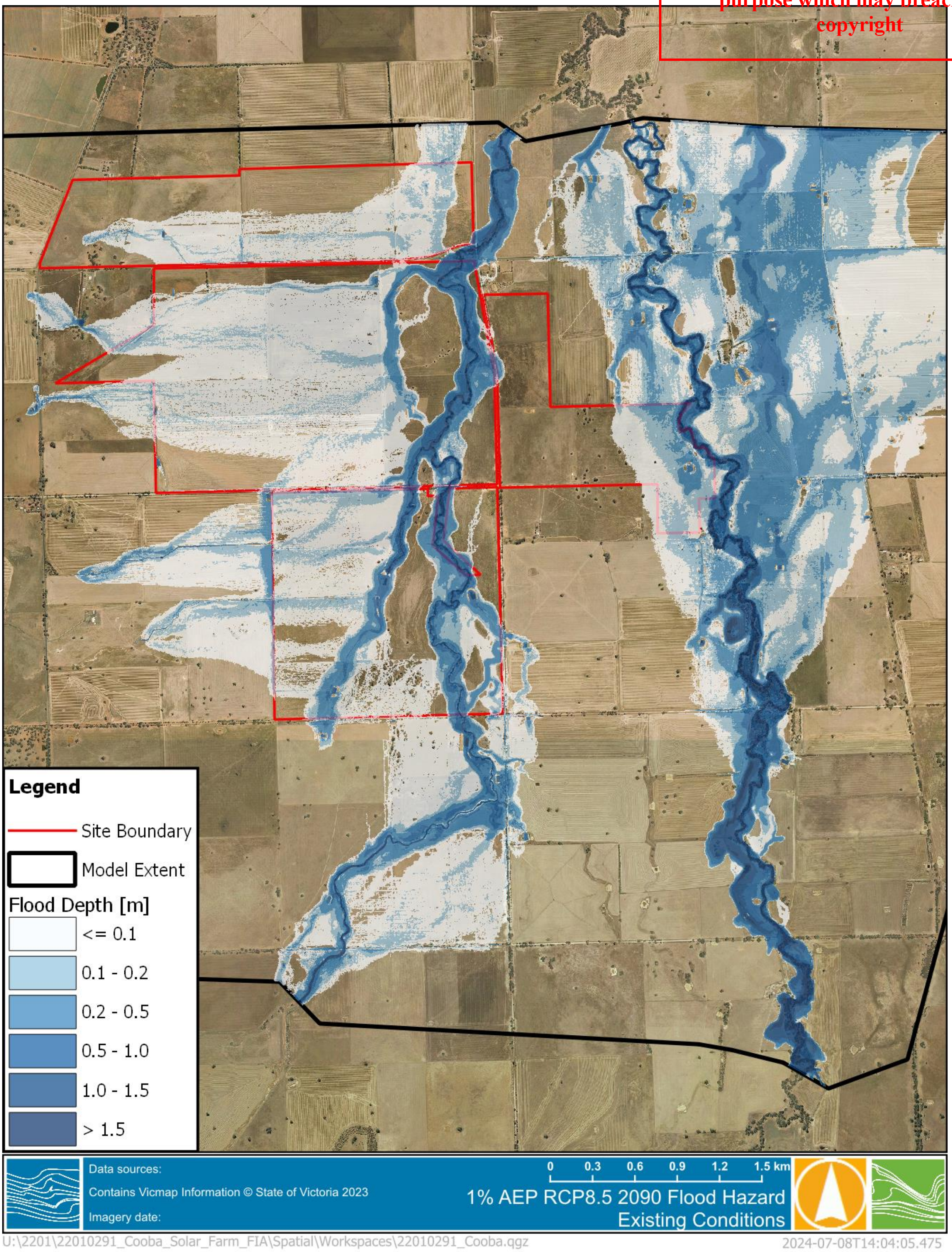

Figure 4-5 1% AEP RCP8.5 2090 Flood Depth – Existing

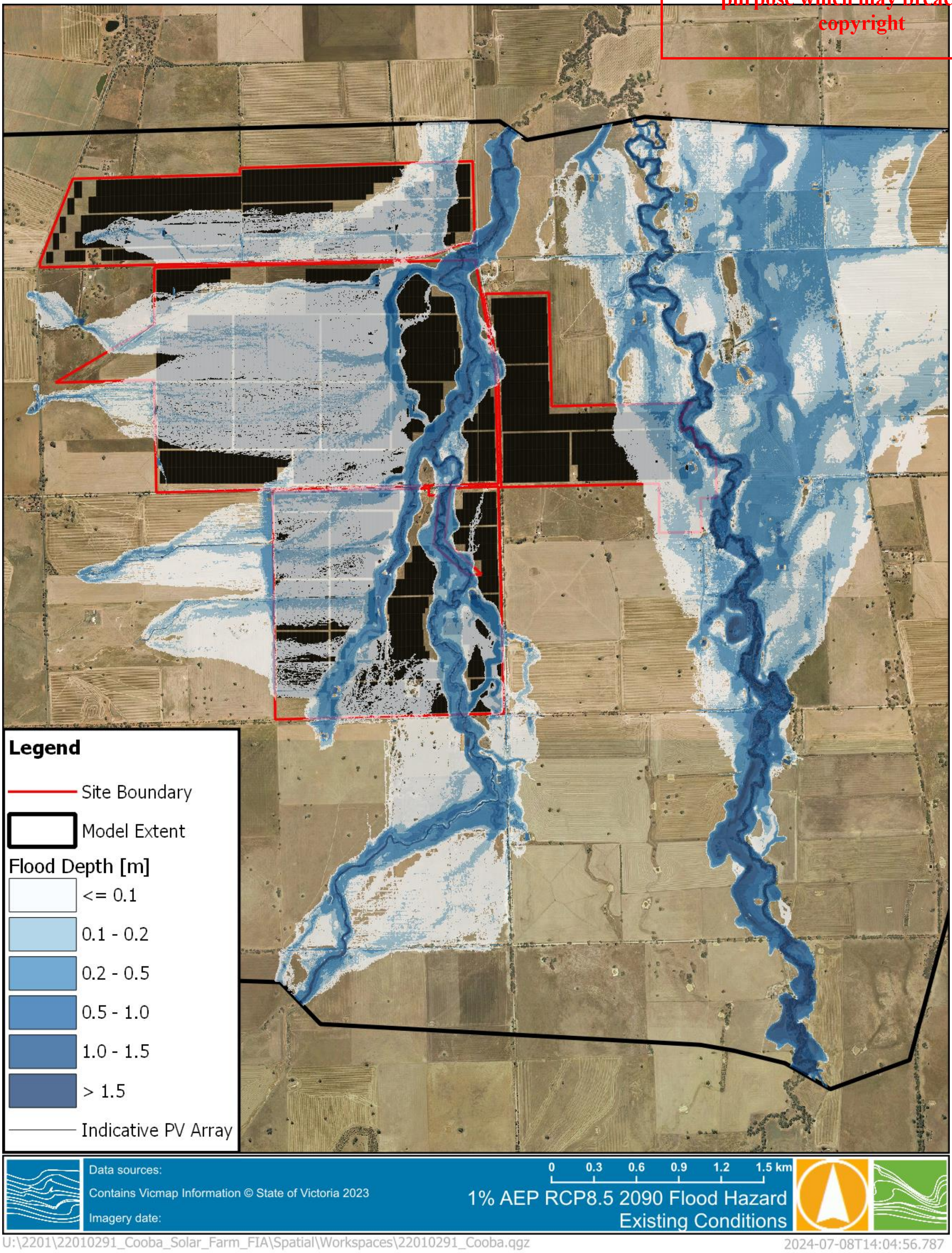

Figure 4-6 1% AEP RCP8.5 2090 Flood Depth with Indicative PV Array– Existing

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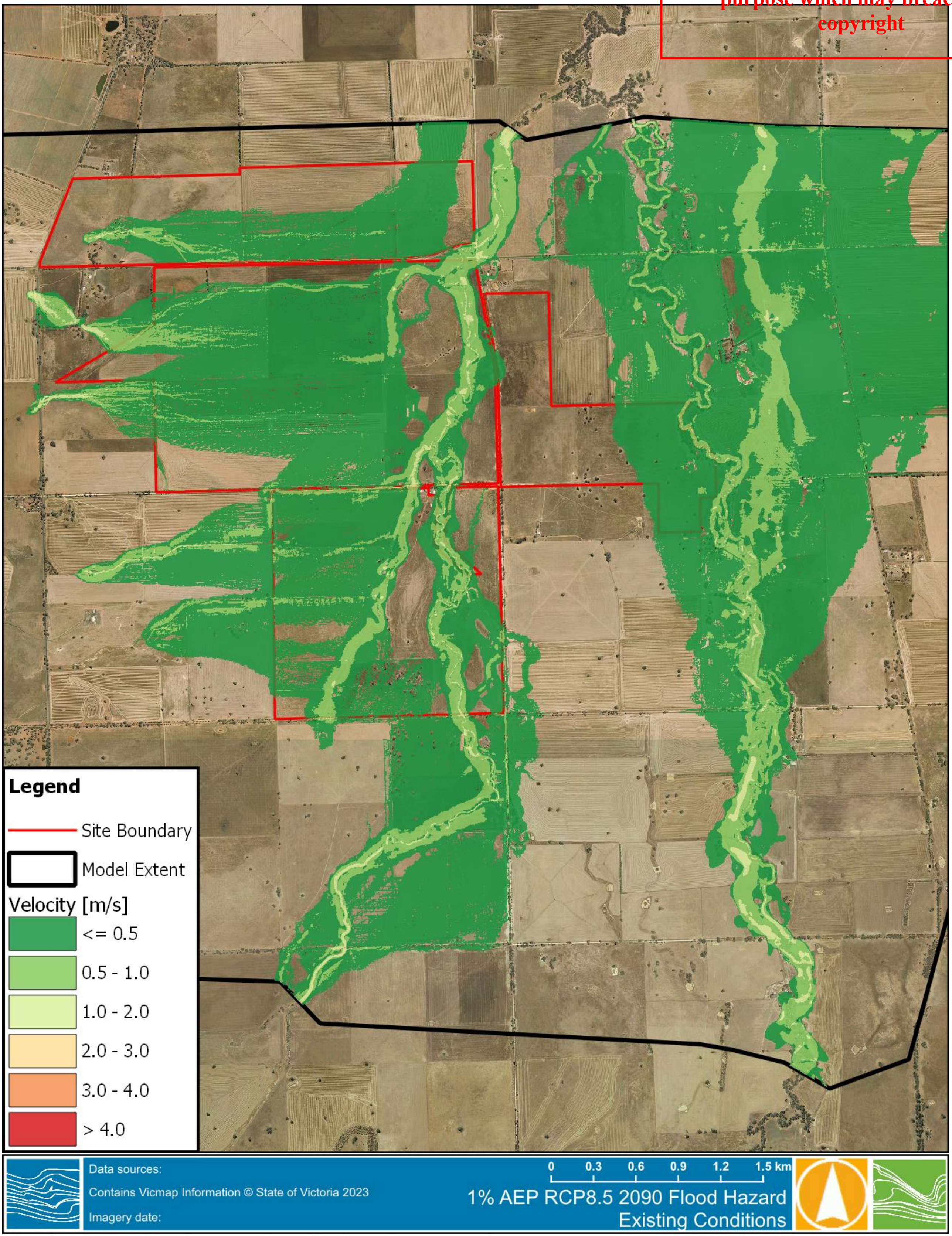

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Figure 4-7 1% AEP RCP8.5 2090 Flood Velocity – Existing

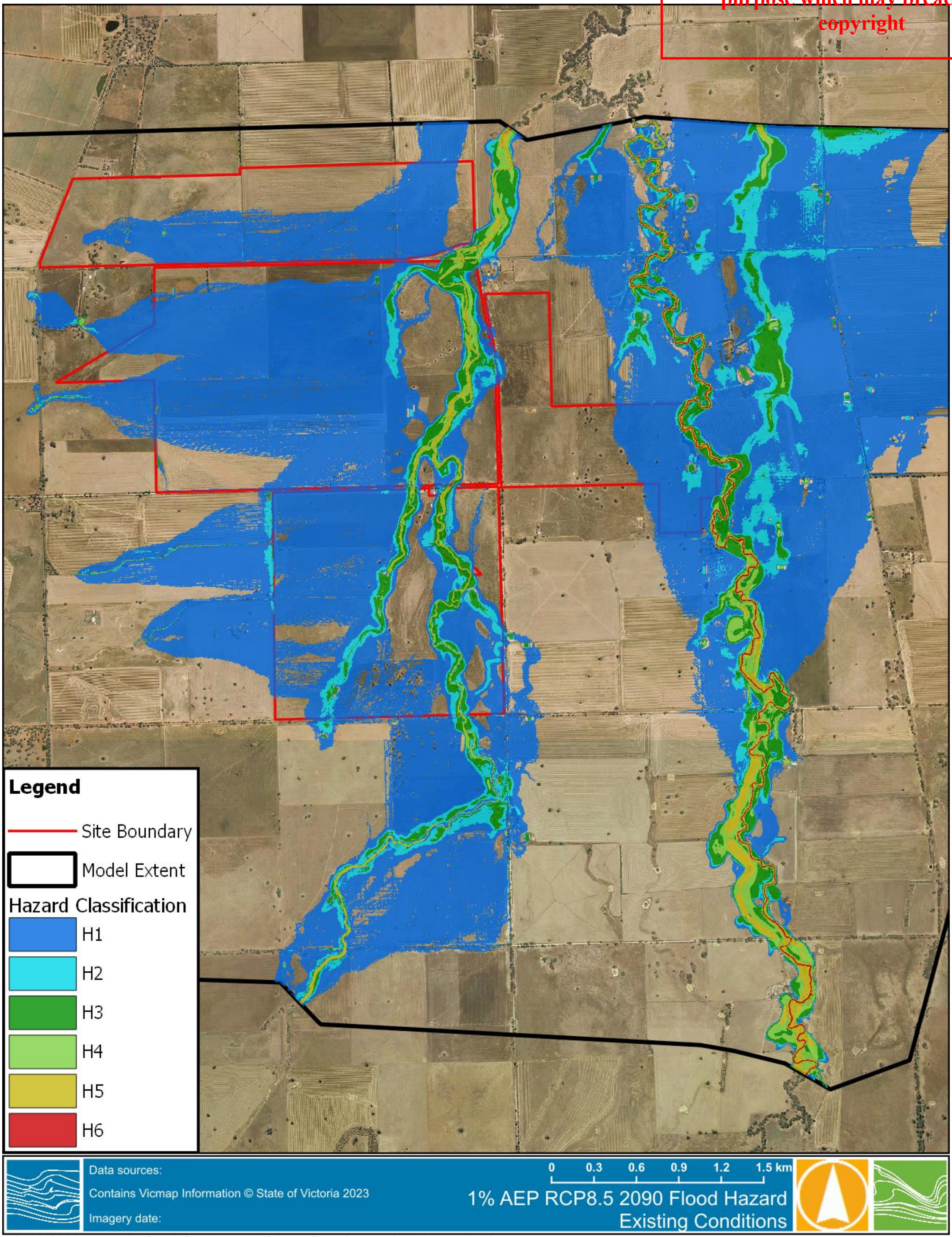

Figure 4-8 1% AEP RCP8.5 2090 Flood Hazard Classification – Existing

5 WATERWAYS INVESTIGATION

5.1 Background

Based on flood impact assessment findings and subsequent discussions with the Goulburn Broken Catchment Management Authority (GBCMA) a site investigation was conducted to describe the "poorly defined waterways" that are mapped within the proposed extent of the solar farm[1]. The work did not seek to determine what is a designated waterway. Hence any descriptors used such as waterway, drain or swale, do not seek to comment on the status of the waterway.

5.2 Site Inspection

The waterways were inspected on the 10th of August 2022, during particularly wet seasonal conditions. Ground conditions were generally too wet for vehicle access and hence waterways were accessed on foot. Survey equipment was not used to measure waterways; hence the depth of waterways was only estimated on-site.

The following general comments can be made on the waterways that were inspected:

- The waterways are described and mapped as either drains or swales (Table 5-1 and Figure 5-1 through to Figure 5-3):
    - The waterways (drains and swales) are all constructed features.
    - The term swale is used where the invert is generally at or close to natural surface level and the primary feature is subtle banks in the landscape, typically 0.2m high, used to confined overland flows.
    - The term drain is used to describe more defined features that are excavated further into the natural surface than swales and thereby, with the additional spoil, have higher banks.
- Whilst conditions were wet, there was no flowing water in any of the waterways. Occasional standing water was observed in drains or swales where there was a low point (e.g. Figure 5-4).
- The drains and swales currently have grazing through the waterway or, if the paddock is in crop, cropping to the top of bank or base of embankment (Figure 5-4 through to Figure 5-7).
- The drainage features do not generally have waterway values. The primary value to be protected in relation to this drainage is water quality.
    - The authors of this report are not specialists in vegetation/ecology. However, it was noted that generally these waterways do not support aquatic type species and typically support the surrounding pasture grasses; potentially indicating they are not wet for most of the year.
- The general purpose of the drains and swales appears to be to concentrate the overland flows that would naturally spread over the landscape. Hence the drainage was constructed to improve agricultural productivity.
    - The landowner described how he and his father had constructed and variously modified the drainage of the property.
    - A reduction in stocking rates during wet or dry periods would benefit the water quality discharging from these waterways. This is not to imply that current stocking rates are excessive.
    - There may be water quality and hydrologic benefits (reduction in peak flows) from demolishing some swales, or allowing them to fall into disrepair; thereby distributing rather than concentrating overland flow.

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[1] Water Technology, 2022, *Memorandum: Waterways Investigation*

- The waterways do not always appear to follow the alignment as mapped.

5.3 Description of Waterways

Table 5-1 Description of waterways

Waterway	Description	Comment
A1 (Figure 5-1)	Swale from upstream dam, that runs across the contours and then down the road. Shallow scooped out swale with spoil on downslope side, typically 4m wide x 0.3-0.4m deep.	No discernible depression above dam at upstream end. There is potentially a spring in the trees upstream of the dam. The upstream reach of this waterway, within the solar farm extent, are simply low points in the topography that are currently cultivated and, despite the wet conditions, show no sign of overland flow through the cultivated soil.
A2 (Figure 5-1)	Small lateral (north-south) drain and A1 transition to this deeper drain typically 6m wide x 0.6m deep.	This drain reduces in depth towards the downstream end where it enters the roadside drainage.
B1 (Figure 5-1)	Swale connecting two dams, typically 8m wide x 0.2-0.3m deep following an ill-defined low point in the landscape. The outfall of the upstream dam is locally deeper (approx. 0.4m deep).	There is no discernible waterway above the dam at the upstream end of B1 and no discernible outlet from the dam at the downstream end of B1 (potentially indicating catchment flows are not large or frequent).
B2 (Figure 5-1)	6m wide by 0.2-0.3m deep swale outfall from the dam (Figure 5-4). Upstream of the dam there is a low point in the landscape from the catchment to the south (separate catchment to B1).	B1 would be expected to discharge into B2 via distributed overland flow during large/intense rainfall events.
C1 (Figure 5-2)	Drain connecting dams, 4m wide x 0.6m deep at downstream end and 2.5m x 0.2m towards upstream dam.	Minor drainage (e.g. 2m x 0.2m) continues north of dam.
C2 (Figure 5-2)	Drain from dam 5-6m wide x 0.4-0.5m deep (Figure 5-5).	This drain discharges into the roadside drainage.
D1 (Figure 5-3)	Drain collecting runoff west of the property. Northern 360m draining north to Myola Road (Figure 5-6). Remaining 1.3kms drains south to swales D2, D3 and D4 that carry flows east. Varies, typically 4m wide x 0.4-0.5m deep. Reduces to 3m wide x 0.3m deep towards D2 and Davey Road.	Connects to roadside drainage at northern and southern ends.
D2 and D3 (Figure 5-3)	Minor cross drainage, barely discernible on the ground. Typically a swale 3m wide by 0.1m deep.	D3 drains to D5 and D2 to dam / D5.
D4 (Figure 5-3)	Swale 7m wide x 0.2-0.3m deep (Figure 5-7).	Largest of the cross drainage from D1. Discharges to dam that is just upstream of concrete drop structure into waterway.
D5 (Figure 5-3)	Swale typically 4m wide x 0.1m deep. Locally can be 0.2-0.3m deep.	Essentially connects two dams. No discernible depression towards Davey Road.

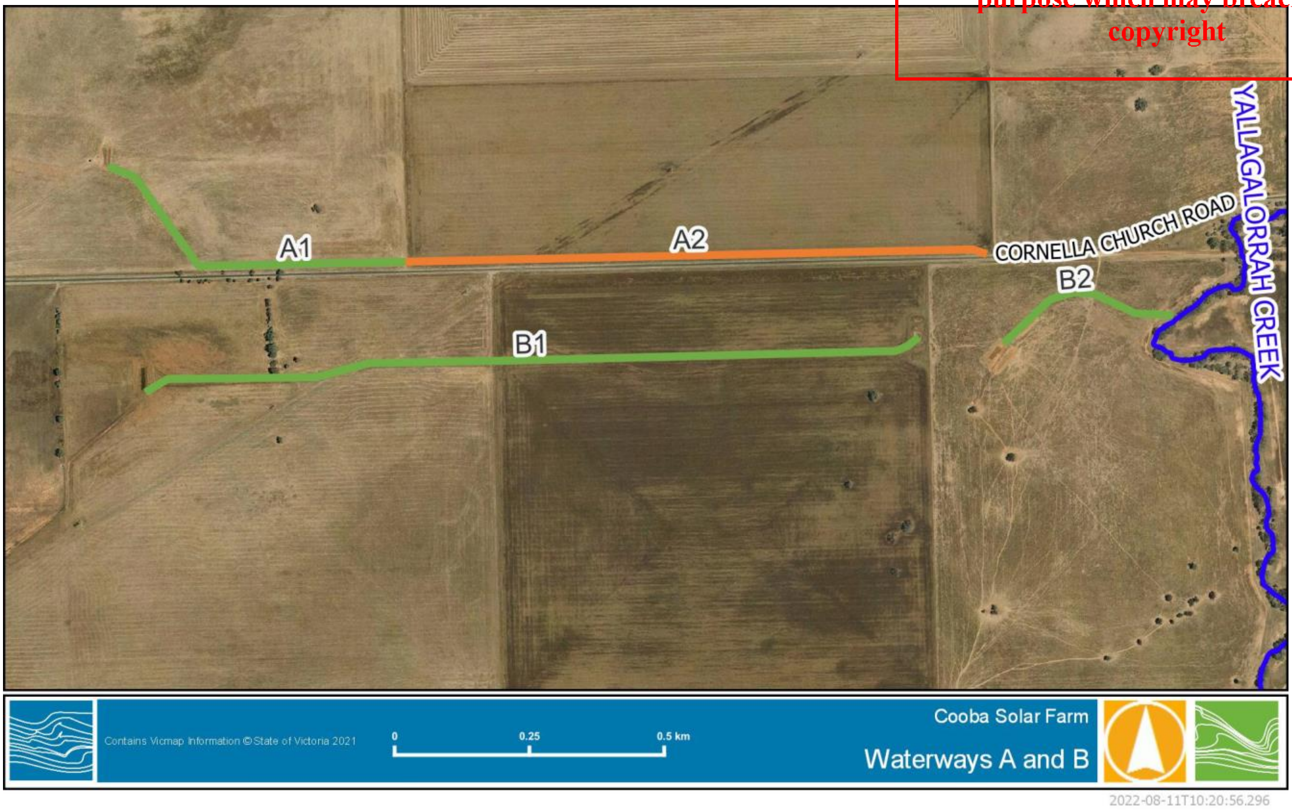

Figure 5-1 Waterways A and B

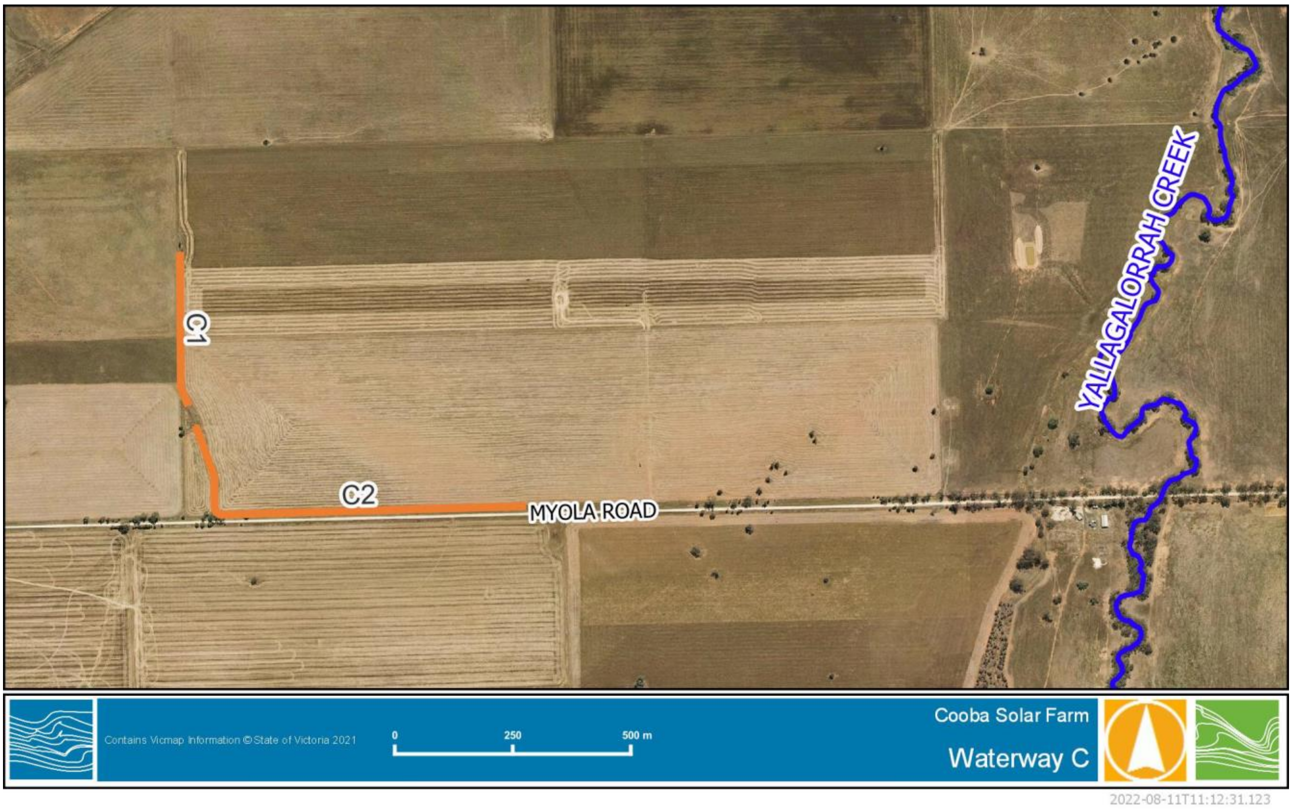

Figure 5-2 Waterway C

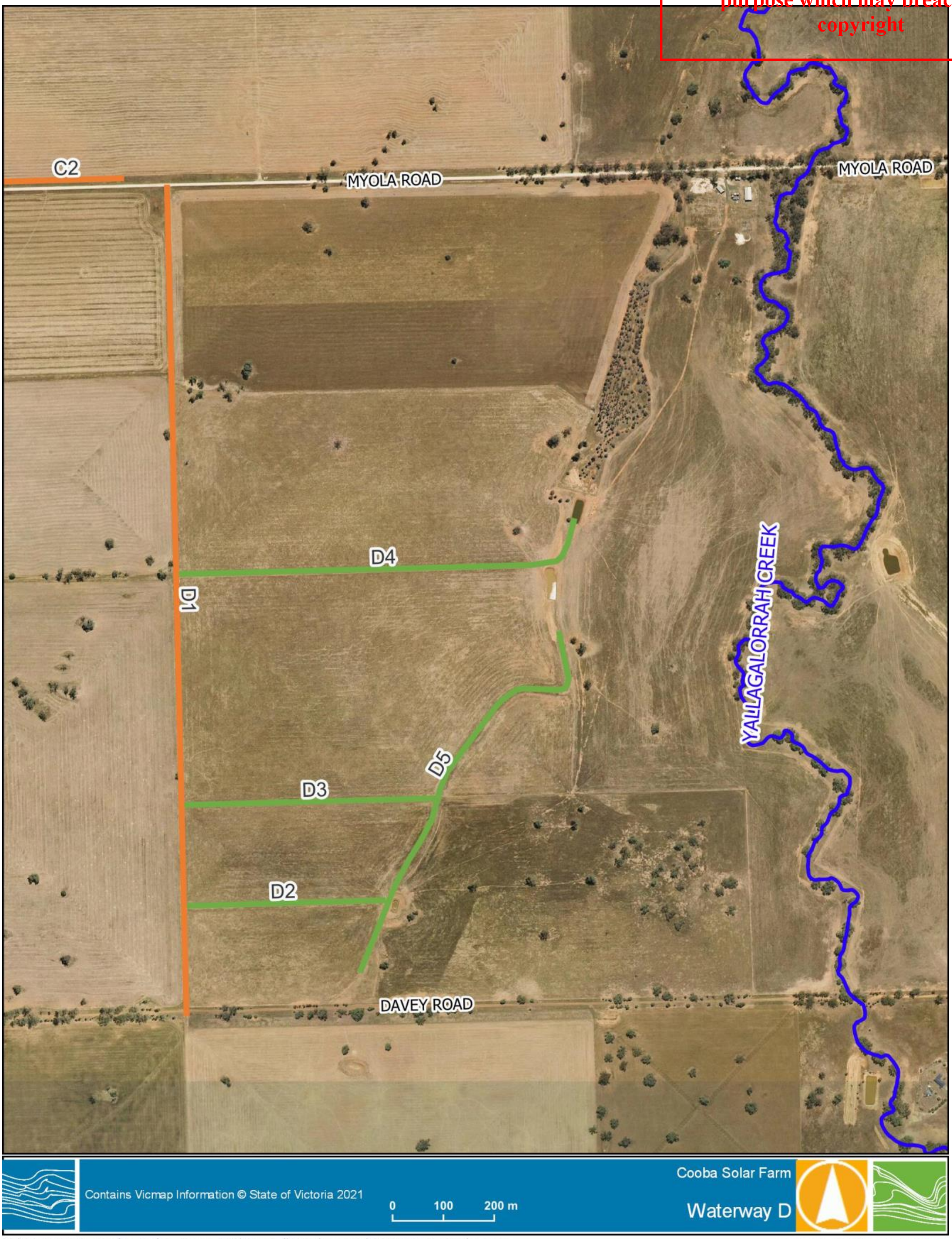

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Figure 5-3 Waterway D

Figure 5-4 Looking downstream (east) along Swale B2. Yallagalorrah Creek in the background.

Figure 5-5 Looking upstream (west) along Drain C2, just upstream of where it enters the road reserve.

Figure 5-6 Looking north along Drain D1. Lone tree in background is Myola Road.

Figure 5-7 Looking downstream (east) along Swale D4. Note wide flat surface of pasture grasses with minor banks intended to confine overland flow.

6 SUMMARY AND RECOMMENDATIONS

A flood impact assessment of the subject site at 124 Cornella Church Road, Colbinabbin was undertaken assessing both riverine and localised catchment inundation. A hydrologic model was established to determine design inflow hydrographs and a hydraulic model was established to identify the flood risk within the subject site.

Hydraulic modelling showed that the proposed subject site has the potential to be partially inundated by shallow localised catchment inundation in a 1% AEP storm event with the maximum depth of 0.2 m outside of river channels, open drain channels and dry riverbeds. The maximum flood velocities observed within the subject site are small outside of the river channels and the flood hazard indicates that a minimum flood hazard category of H1 is identified.

Additional model runs considered the impact of increased rainfall intensity under projected climate change in accordance with the ARR2019 guidelines. Modelling shows minor increases in flood depths, levels and velocities in the climate change scenario, with increases in flood extent most prominent in the areas adjacent to the waterway and in the breakout east of Cornella Creek.

Further to the hydraulic modelling, a site inspection was conducted to investigate the status of mapped waterways within the proposed subject site.

The following recommendations are made based on the findings in this report:

- A setback of 30 m from top of bank is recommended for the Cornella and Yallagalorrah Creeks.
- For the smaller waterways identified in the waterways investigation, the recommended setback is likely to vary across the site. The layout of the solar farm, including placement of panels, batteries, switchboard, amenities and maintenance areas should be designed to be placed outside of the top of banks of the waterways as these waterways typically provide drainage a function but are unlikely to have ecological value. The banks can be identified in the field using the descriptions in Table 5-1.
- It is understood that the substation needs to be placed close to the transmission line easement near Cornella Church Road, which requires rerouting of the B1 swale identified in Figure 5-1. The rerouting should maintain the drainage function of the swale where possible maintaining the same typical cross section of the waterway. The proposed diversion alignment is shown in Figure 6-1. Any roadways or access tracks crossing the waterways should also ensure they are designed to maintain the drainage function of the waterways.
- It is also recommended that solar panels and other critical infrastructure be raised sufficiently above the 1% AEP flood levels. Solar panels should be at least 300mm above the 1% AEP (with climate change) flood level at its lowest level or 150mm above the natural surface (where flooding is not identified). Sensitive infrastructure (battery/substation etc.) should be at least 300-500mm above the 1% AEP (with climate change) flood level. The flood modelling results identified in this assessment can be used to assess the need for stormwater infrastructure including roads which may cross overland flow paths.

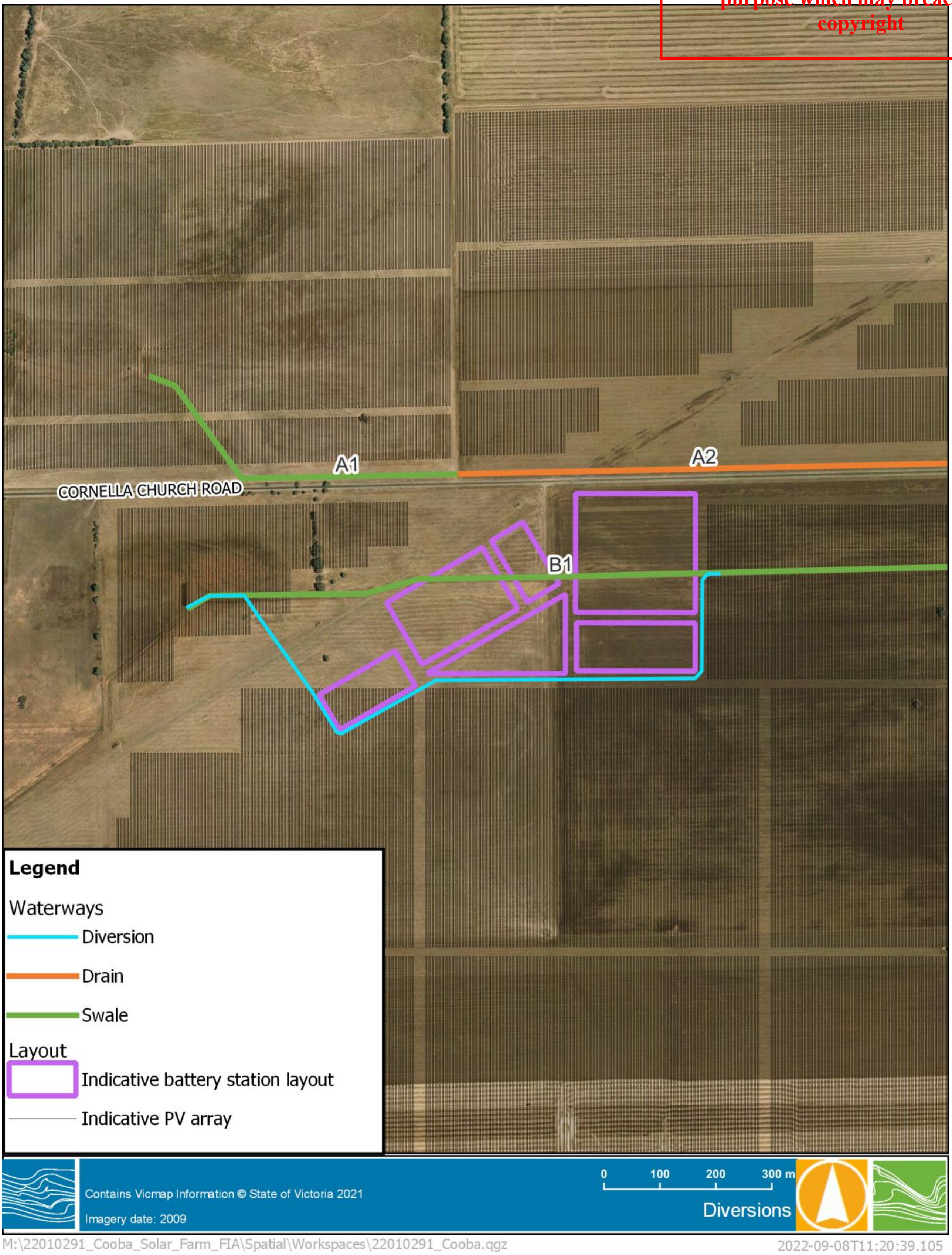

Figure 6-1 B1 diversion

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